Spring 2015

# Liberty Valley Church Network

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**Project Plan**

Project Name: Liberty Valley Church Network

Team Member: Tim Fuhry

Project Description: Design and partially prototype a small church network

Location of Work: Home, University of Akron Polsky M155

Existing Equipment, Infrastructure, and Software: 2 Laptops with Windows 7 (one using a virtual machine with Linux Server) will be used. A switch may be acquired, possibly from the University.

Detailed Objectives:

1) Research
    a. Detailed requirements of network components
        i. Server and operating system
        ii. Switch
        iii. PCs
        iv. Number of Wireless Access Points
        v. ISP
        vi. Storage
        vii. Printing
    b. Network examples
    c. Cost of network equipment and testing
    d. Implementation procedures
        i. Server and operating system
        ii. Switch and network
        iii. Storage
        iv. Future expansion capabilities
    e. Troubleshooting techniques

2) Design
    a. Computer room
        i. Hardware
        ii. Linux operating system
    b. Networking and IP addresses
        i. IP address design
        ii. Switch ports
        iii. Cabling
    c. Users and requirements per location
    d. Application and miscellaneous software
    e. Protocols and required configuration

3) Implementation
    a. Install hardware
        i. Server
        ii. Switch
        iii. Example User PC
        iv. Storage drive
    b. Connect hardware with cables
    c. Install Linux on server
    d. Configure Linux for networking
    e. Configure switch for networking
    f. Add storage device
    g. Configure other devices

4) Testing
    a. Verify server hardware
    b. Test Linux server functionality
    c. Test switch operation
    d. Verify cable design
    e. Test physical connections
    f. Test network connections in software
    g. Test computer software operations
    h. Verify network design
    i. Test storage functionality
    j. Test performance

5) Documentation
    a. Project plan
    b. Building and network diagrams
    c. Prototype diagram
    d. Hardware list
    e. Software list
    f. Network design documentation
    g. Linux configuration
    h. Storage configuration
    i. Project verification

Estimated Times (in hours):

| Objective | Research | Design | Implementation | Testing | Documentation | Total |
|---|---|---|---|---|---|---|
| Total | 40 | 10 | 30 | 40 | 20 | 140 |

**Project Analysis**

The prototype network in the project was built with two computers and one switch. One computer was a server running Ubuntu (prototyped using a virtual machine). The other computer was a Windows client. Both were connected to the switch, which provided access to the Internet. A printer was also connected to the switch. The actual network should look similar to this prototype but with several more computers and a projector connected to the network.

Final network design

The network will be implemented in a new building. The requirements of the network include at least six PCs, Internet access, suitable storage, one printer with some other functions, wireless access, and all necessary networking components. A file server and print server will be necessary for the network. Some security and the ability for future expansion are required in the networking configuration.

Prototype Design

The prototype included one client PC and one server PC. The server was configured with all the features that were important for the network. They were both connected to a switch that provided access to the Internet. This switch was configured with appropriate networking features. A printer was also connected to this switch. The rooms represented in this prototype were a computer room where servers and networking equipment will be installed, an auditorium where the church assembles, and some separate offices and classrooms. The server and all of the networking equipment would be in the computer room, while the client PC would be in one of the offices.

Hardware Implementation

First, the hardware was procured and set up. The client computer running Windows 7 was connected to a switch, and Ubuntu Server was installed in a virtual machine on the other computer. This computer was then connected to the switch as well. These computers were similar to computers that could be used in the actual configuration. The switch in the center of the network was a Dell Power Connect 5324 switch. This type of switch could be suitable for the network design. The server was configured first. Next, the client was configured and then Internet access. The Officejet printer that was used could be considered suitable for the network printing tasks. Other networking components were basic cables and preexisting standard Internet access components. A Linksys E3000 router was available to connect the switch to a DSL connection. This router could also be used for wireless connections. In the actual network, wireless access points might be sufficient. No problems occurred with these connections.

Server

On the server, Ubuntu was installed in Virtual Box. This was a basic installation of Ubuntu Server, and no problems occurred. One user was set up as an administrator, and one was set up as a standard user to demonstrate complete functionality of the server. In the final network, the

administrator account will be used for configuration and maintenance of the server. Some other users who would need to access the server for some reason could use a standard user account. The file server and print server were considered important for the network. The file server component of Ubuntu was set up. By using a file server, network users could store their data centrally at the church without accessing the server directly. In the final network, this might be accomplished by accessing a wireless component of the network with a user's personal computer. In addition, printing and similar functions were needed on the network. This was demonstrated by setting up a print server. Setting up these important functions helped prepare for configuration on the actual network.

Switch

It is possible that the church will grow and need to expand the size of the church building. For this future expansion, configuring multiple networks from the switch was considered important. In the prototype, the switch was configured with separate VLANs for different networks. Two VLANs were configured on the switch. In addition, security was an important aspect of the network. Unfortunately, the switch that was used did not have as many configuration options for networking and security as newer switches. However, some security measures could be implemented on the switch. In order to protect the switch from unauthorized access, passwords were set up on the console. Ports and VLANs were given some security configurations. These were designed to limit access to the network to those who were authorized to use the network.

Summary

The prototype implementation went well. By studying both problems and successes, the work on the prototype helped demonstrate how to perform the procedure on the actual network. The prototype was configured with the features believed most important for the final network. By seeing how well these features worked, it was determined which features to spend the most time on in configuring the production network and how to make these features work. In addition, different network designs were studied for the project, and the most suitable design could be selected for the final network.

**Project Presentation**

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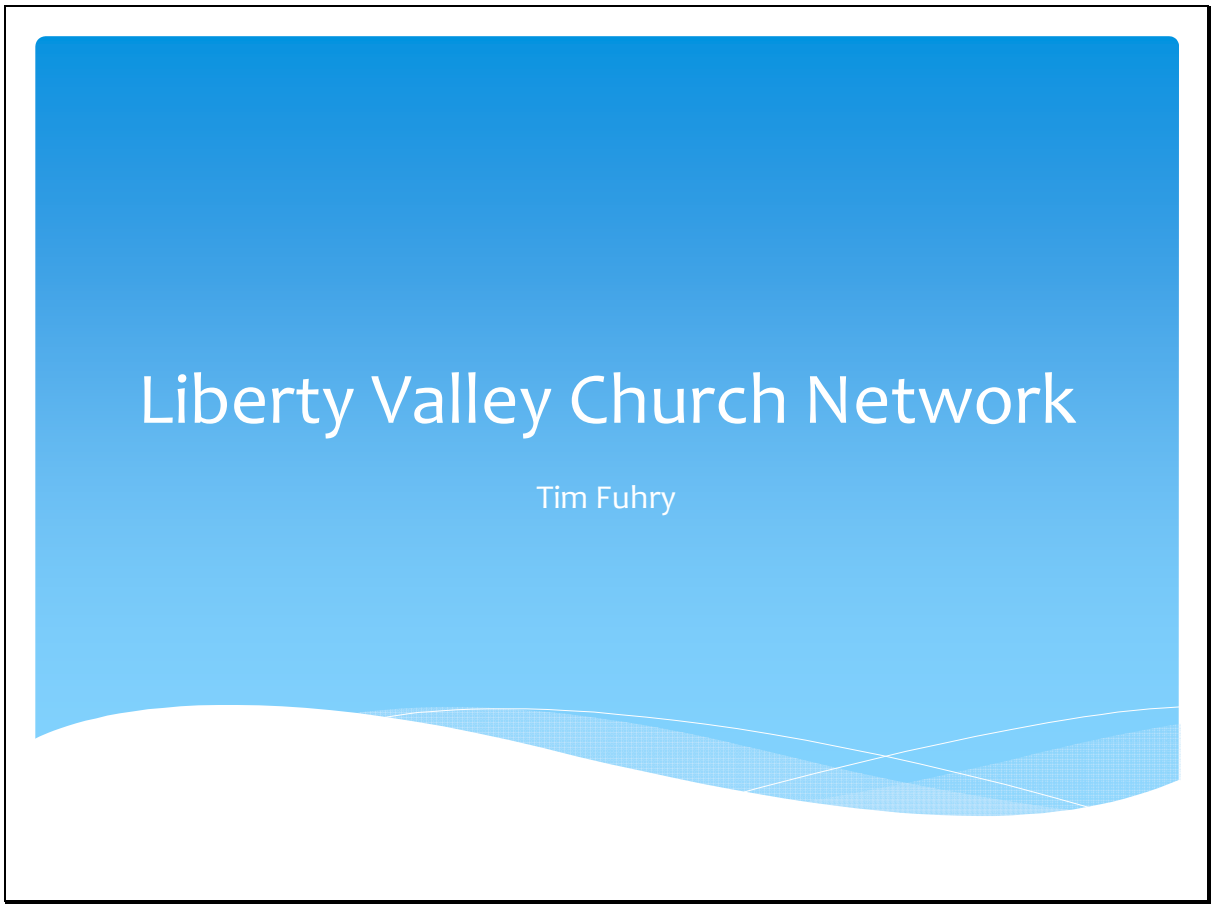


Slide 2

# Purpose

* New church building currently being planned
* Church building requires network design
* Project Purpose: Design and prototype a small network for new building

Slide 3

# Project Approach

* Draw diagrams for prototype and final networks
* Choose hardware and software components
* Acquire hardware and make connections
* Configure all devices on network
* Verify operation of network and troubleshoot

Slide 4

# Prototype Hardware List

* PC with Ubuntu Server as server
* PC with Windows 7 as client
* Dell PowerConnect 5324 switch
* Linksys E3000 wireless router
* HP Officejet 6310 All-in-One printer
* Western Digital storage device
* Associated cables

Slide 5

# Hardware Connections

* Switch connected to two computers, router/Internet, printer, and storage device
* Other computers could be connected to wireless router
* Separate computer attached to switch console port for configuration

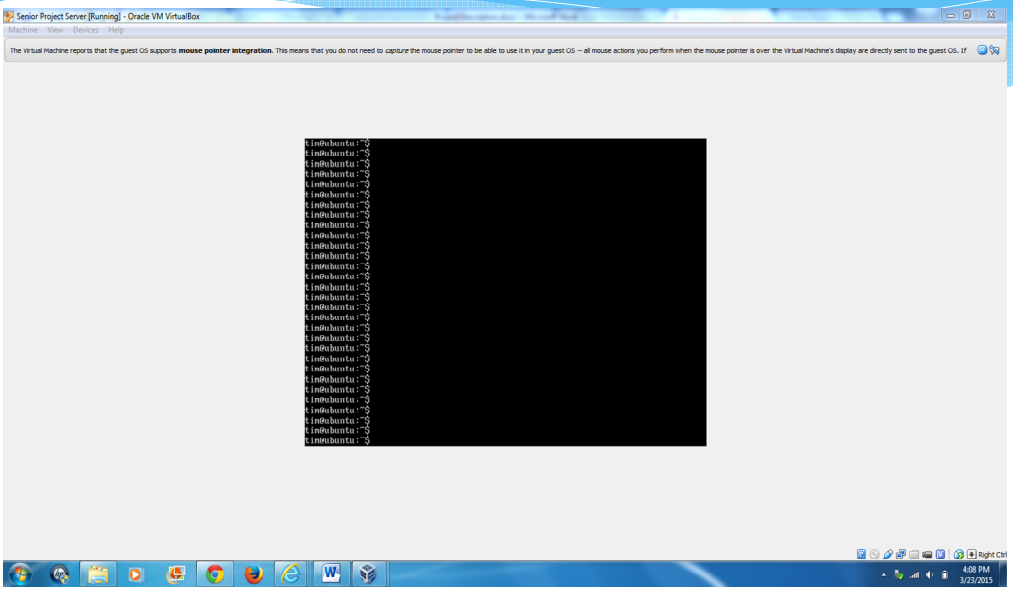
Slide 6

# Ubuntu Installation

* Ubuntu server installed in virtual machine
* Server set up with basic configurations
* User accounts set up for standard and administrator users
* DHCP configured for network interface

Slide 7

# Ubuntu Server



Slide 8

# Client Configuration

* Client set up with Windows 7 installation
* Client  set up with basic user configuration
* Client configured to connect to network with DHCP

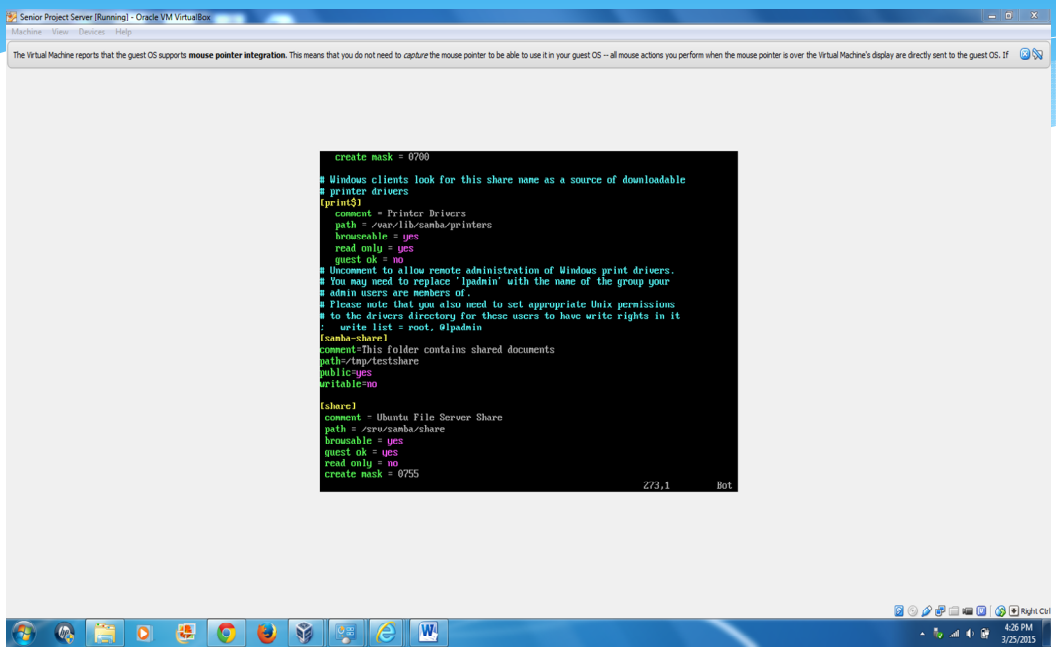
Slide 9

# File Server

* Samba installed  on server
* /etc/samba/smb.conf modified to point to network shared directory for file server capability
* Shared directory created on server

Slide 10

# File Share Configuration



Slide 11

# DHCP

* Final configuration used wireless router for DHCP
* However, server could also be configured as DHCP server for network
* DHCP server ability installed on server
* Configuration file /etc/dhcp/dhcpd.conf modified to set up DHCP

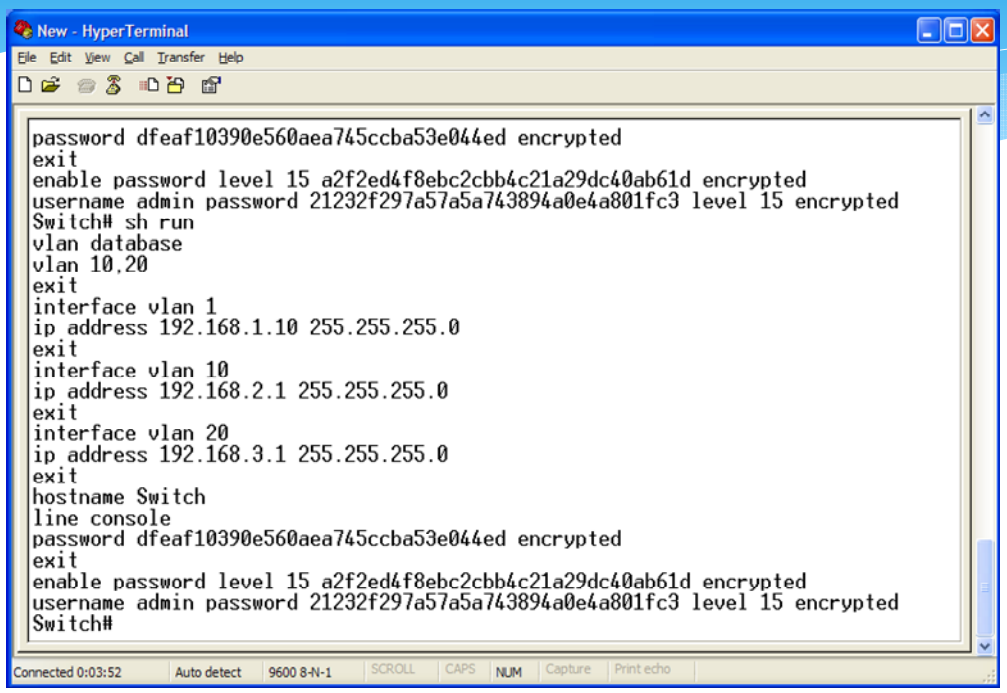
Slide 12

# Switch Configuration

* HyperTerminal used on Windows XP computer to configure switch
* Switch provided with basic hostname and passwords
* VLANs configured and set up for inter-VLAN communication

Slide 13

# Configuring the Switch



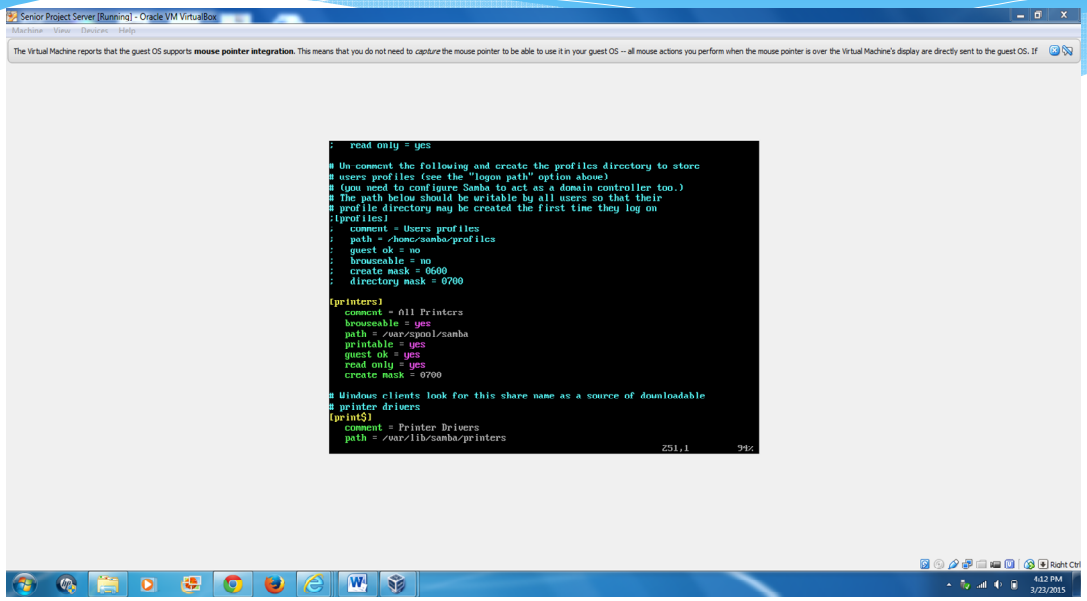
Slide 14

# Printer Configuration

* Samba Print Server configured for network
* Configuration file previously used for file server configuration was modified to add print share
* Printer could be added  on server and shared with network clients

Slide 15

# Samba Print Share



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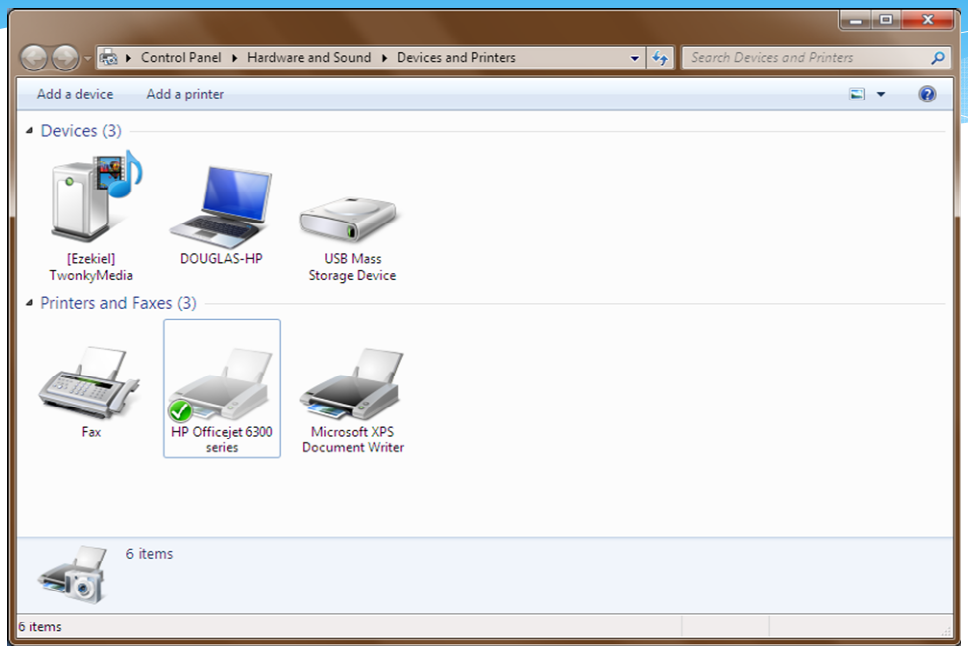
# Client Printer Access



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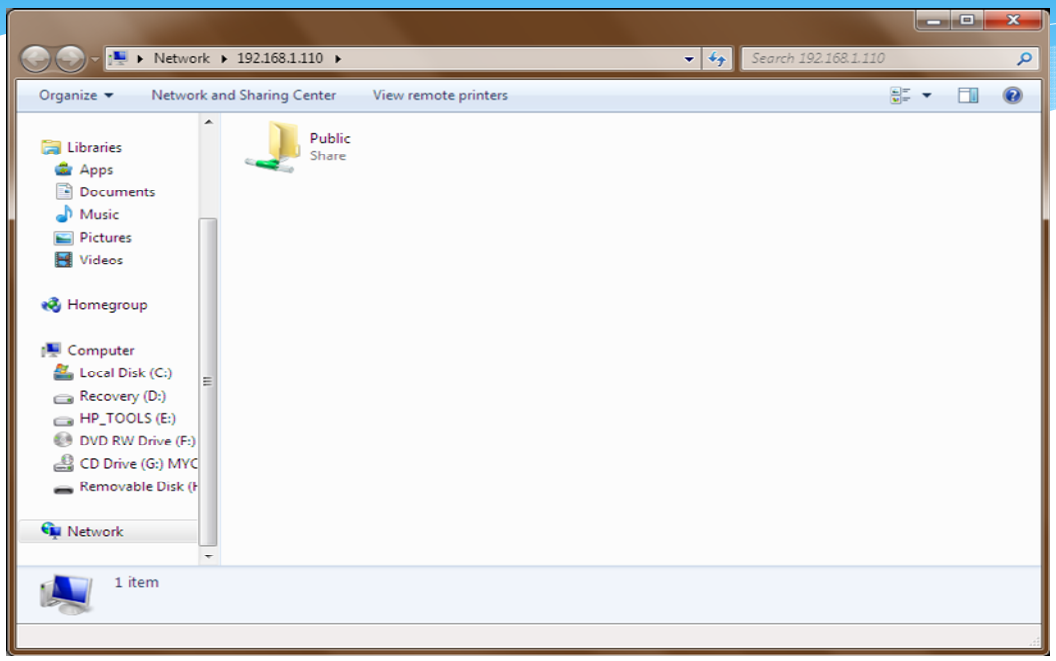
# Storage

* Storage device was used on network
* Storage could be accessed from clients that were connected to switch
* This Network Attached Storage could be used for backup purposes

Slide 18

# Storage Device Client Access



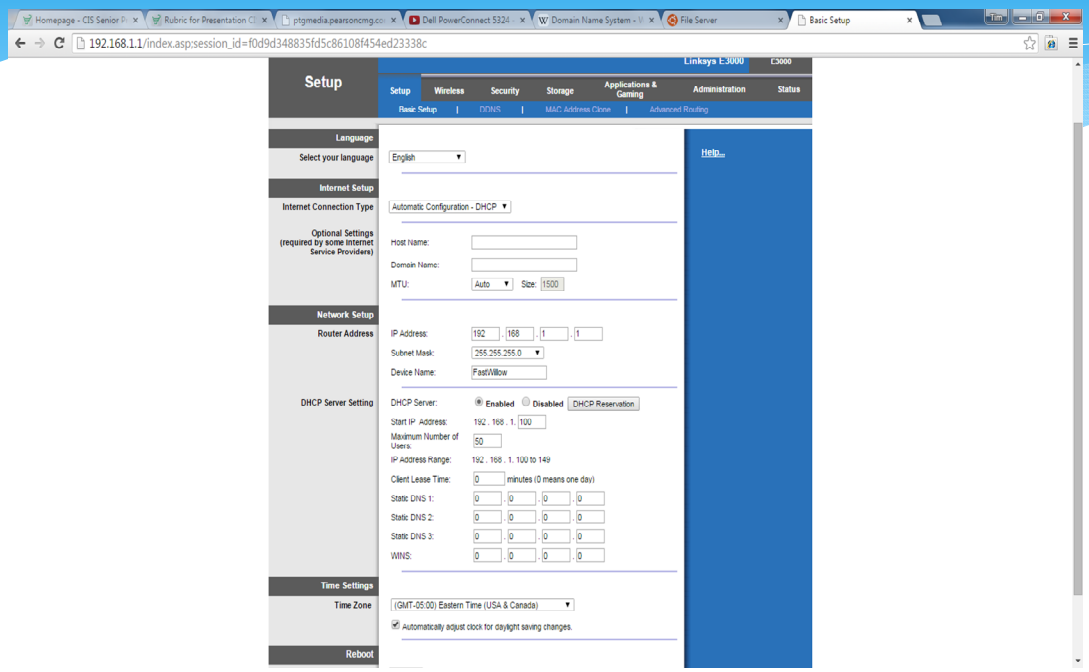
Slide 19

# Wireless

* Wireless router was connected to Internet
* DHCP configured on wireless router to assign address range of 192.168.1.100 to 192.168.1.149
* Security and other functions set up on router
* All network components functioned when connected to router on wired network or connected on wireless network

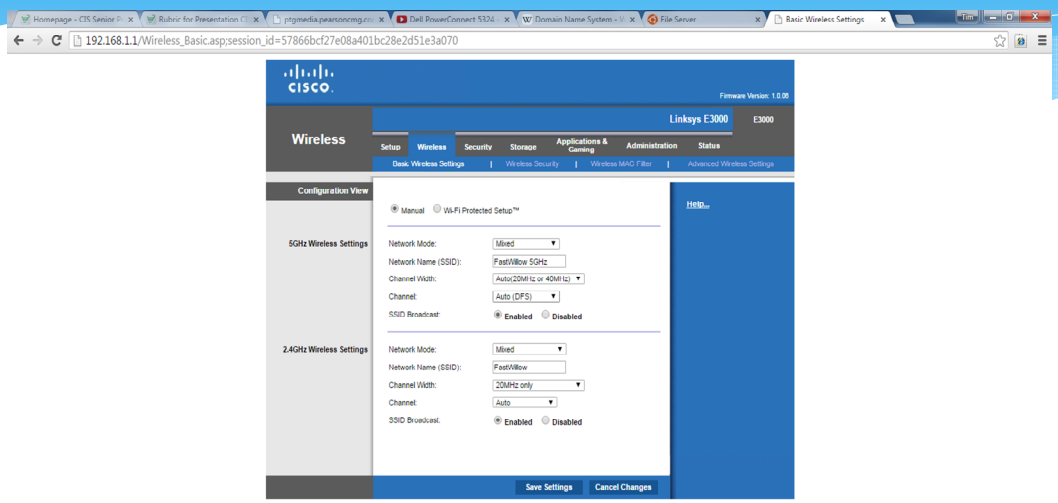
Slide 20

# Router Configuration



Slide 21

# Wireless Configuration



Slide 22

# Analysis of Project

* Research time in project work was valuable for learning which configurations would be best for final network
* Project prototype functionality helped to make decisions for final network
* Hardware components will be similar in final network
* New switch with more features will be acquired for final network
* Linux server worked well with Windows clients
* Ricoh printer will be used for final network
* New backup device to be used for final network not yet determined
* Projector will be added to final network
* More clients will be in final network

Slide 23

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## Project Description

Building Diagrams

Although the building construction has not yet begun, some basic planning diagrams have been completed. These are shown here. Since the building is still in the planning process, detailed schematics have not been provided.

**Figure 1. Land where the building will be**

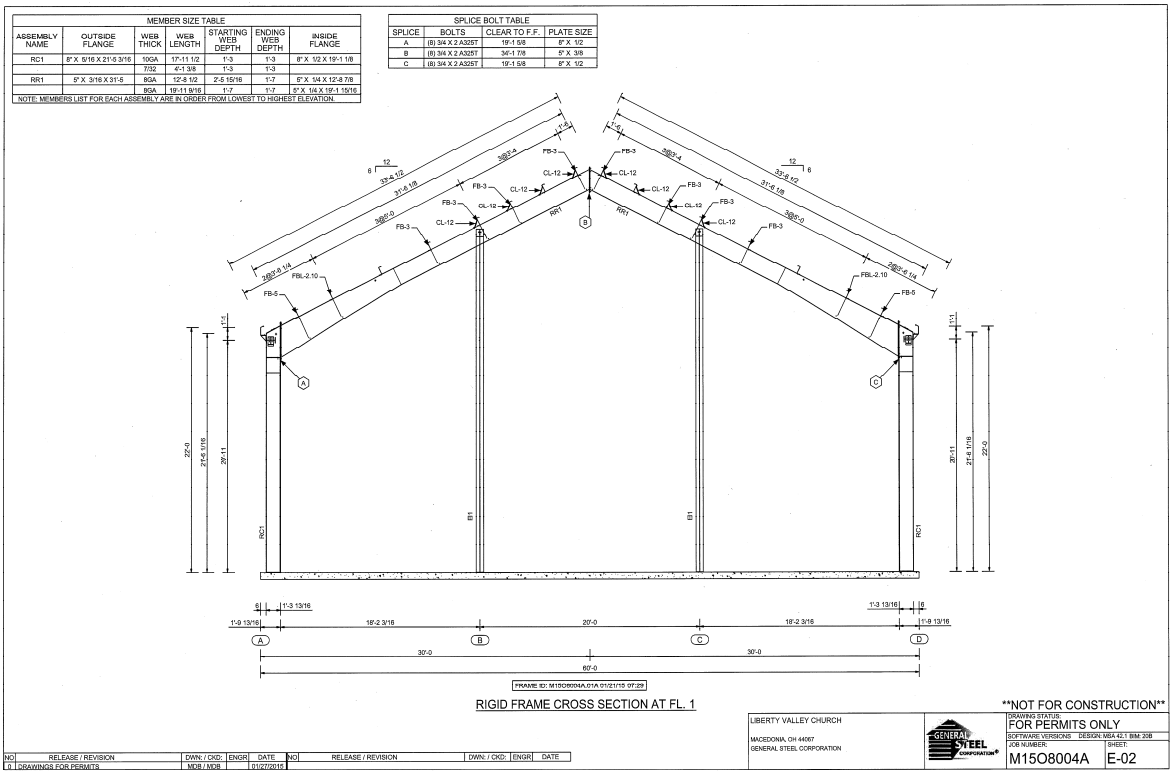



**Figure 2. Current diagram of building**

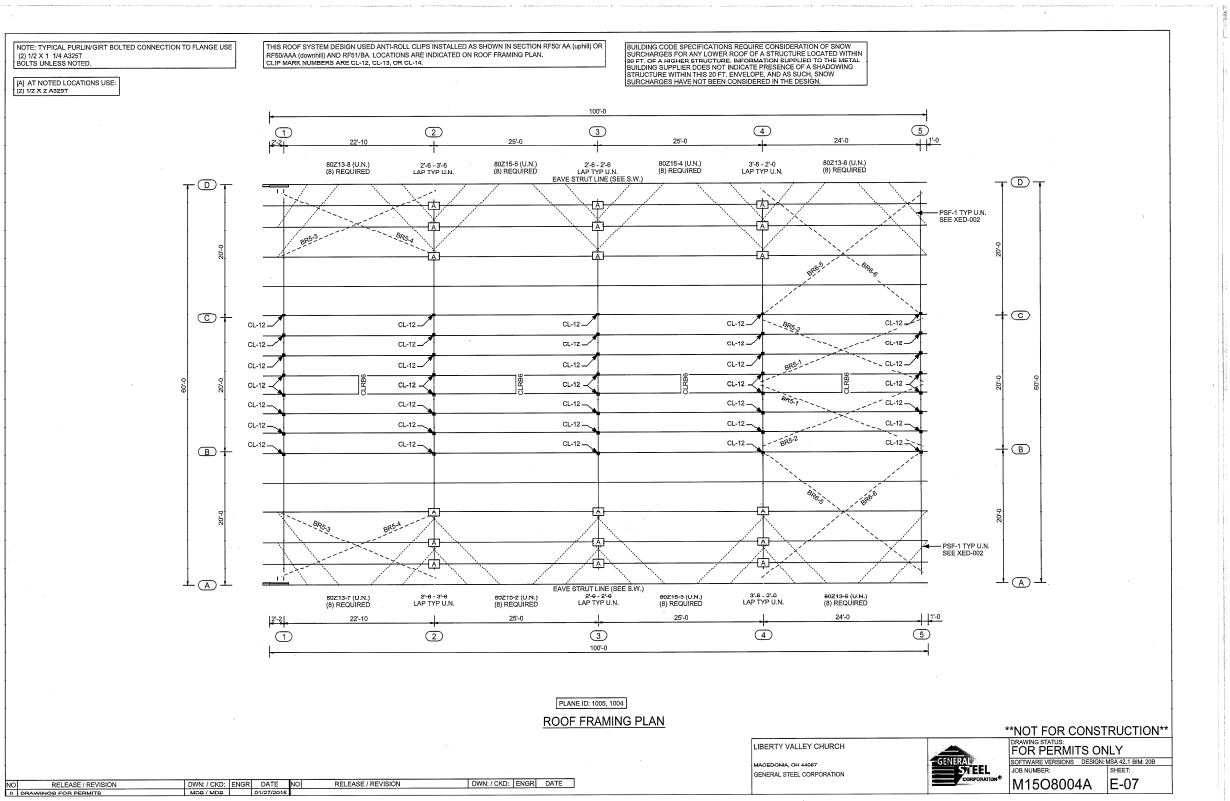
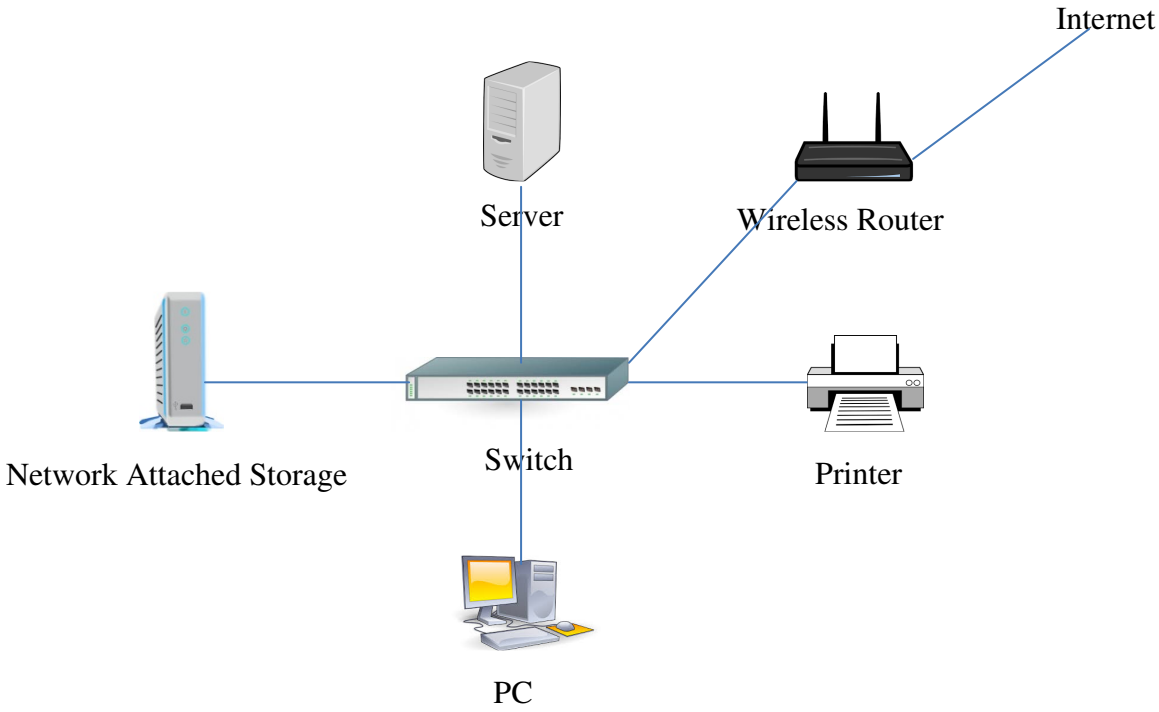


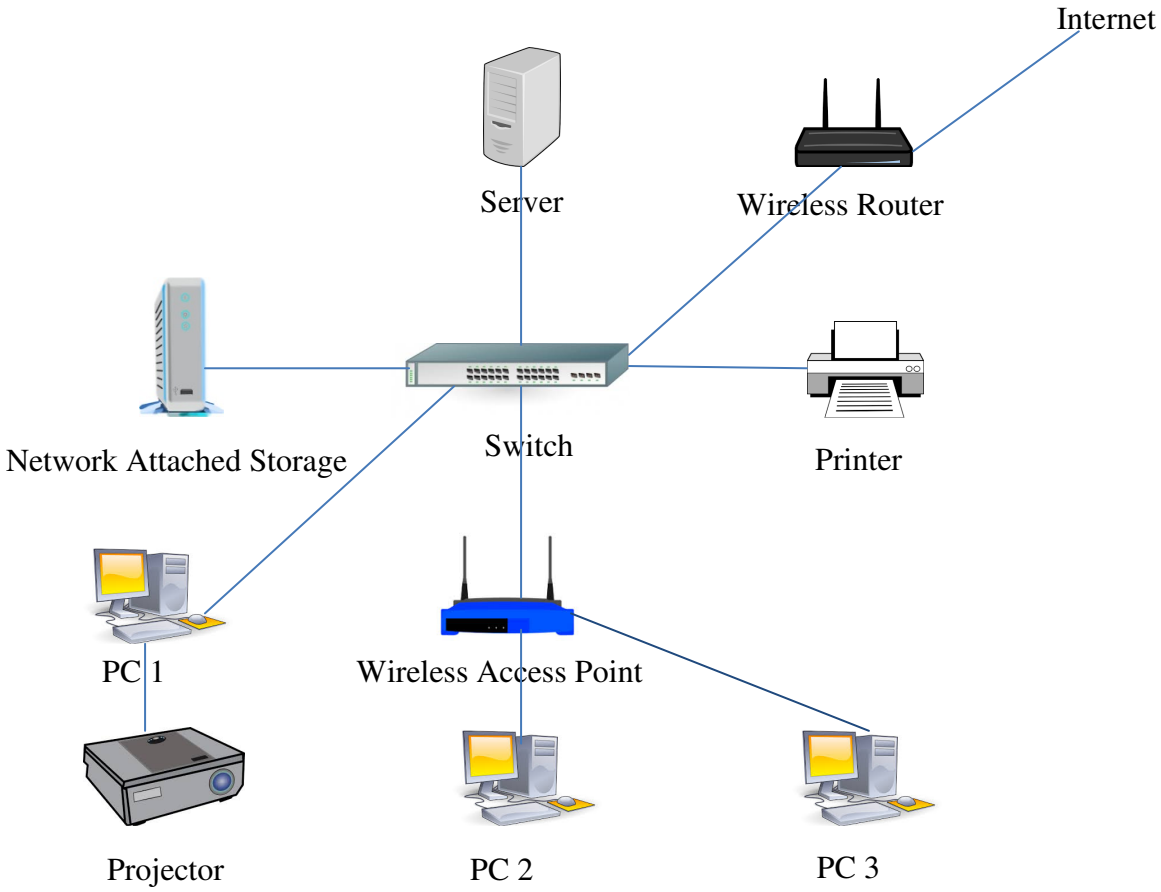

**Figure 3. Current diagram of building**

## Network Diagrams

This is a diagram of the prototype that was configured:



The final network should look similar to this, except with more PCs:




<u>Costs</u>

For the final network, prices for components were researched to determine approximately how much it would cost to set up a basic network. These were costs determined for the final network components:

- Switch: $160
- Server: $480
- 3 PCs: $435
- Printer: $65
- Backup Storage Drive: $55
- Projector: $315
- Wireless Router: $124
- Additional Wireless Access Point: $25
- Cat 5e network cables: $20
- Total Cost: $1679

The prices listed here are not definite. These prices were taken from checking current component prices on Amazon to keep them consistent. Some more components could be added to the network design after the building is completed.

## Hardware Installation

For the prototype, two PCs running Windows 7 were acquired. One Dell PowerConnect 5324 switch was acquired. Two network cables were connected from the computers to the switch. An HP Officejet 6310 printer was connected by a network cable to the switch. A storage device was connected to the switch. Finally, the switch was connected to a broadband modem leading to the Internet. Another computer was connected to the console port on the switch in order to configure the switch.

**Figure 4. Project prototype setup**

## Switch Configuration

The switch was configured from a separate computer running Windows XP that was attached to the console port. A serial-to-USB adapter was used since this computer did not have a serial port. A null modem adapter was also attached to the end of this cable in order to make it usable.

HyperTerminal was started, and a session was established to the switch from the computer on the COM3 port.

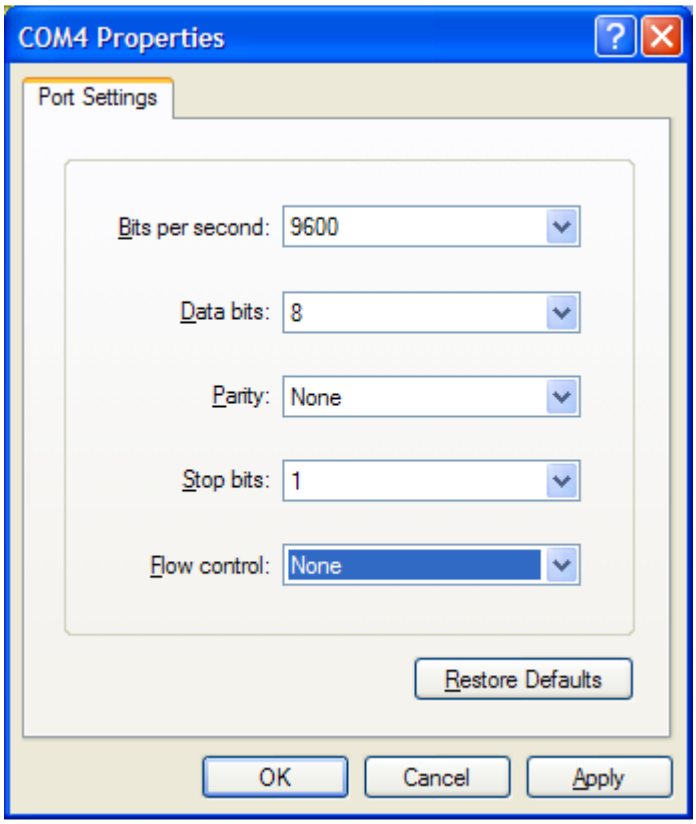



Figure 5. Connecting to the switch

The switch allowed commands to be entered by using the enable command and then the configure command to enter configuration mode. First, some basic commands were used on the switch. It was given a name using the hostname command in configuration mode. The enable mode was protected with a password by using the enable password command in configuration mode. From configuration mode, the line console command allowed configurations for console access. The password command was used here to prevent unauthorized users from accessing the console.

VLAN 10 was created from configuration mode using the command vlan 10. VLAN 20 was also created. These VLANs could be used on the switch to simulate separate networks. Because a limited number of devices and ports were available, no other device was available to demonstrate this. However, computers in the final network could be placed on different VLANs for security or expansion purposes. SVIs were created using the commands int vlan 10 and int vlan 20. IP addresses could be configured on these SVIs to connect different computers to different networks.

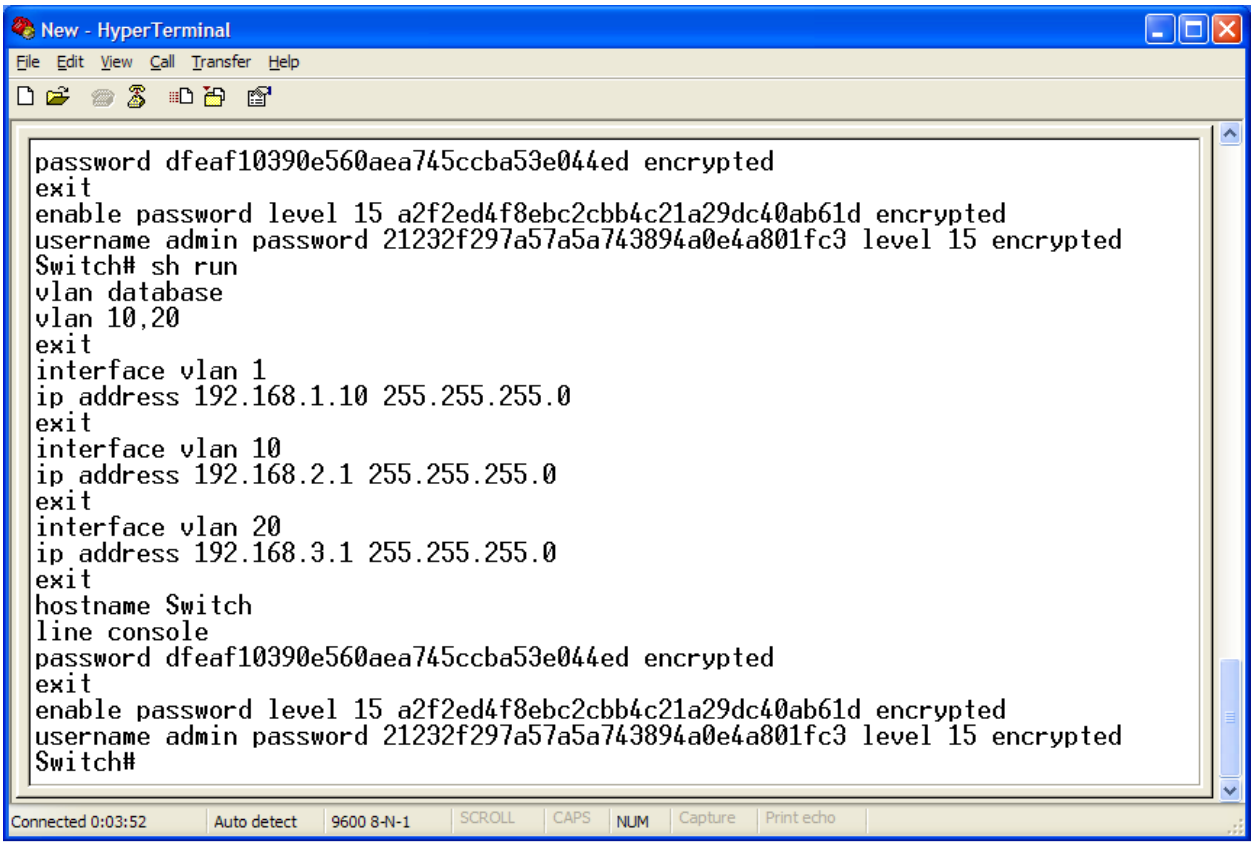



**Figure 6. Basic configuration on the switch**

## Client Configuration

One computer with Windows 7 was used as the client. This computer was set up with basic configurations and configured to connect to the Internet using a DHCP address from the router.

## Server Configuration

VirtualBox was installed on the other Windows 7 computer. Ubuntu Server 14.04 was downloaded from Ubuntu.com and was installed in a virtual machine on VirtualBox. This setup could accomplish all the necessary server tasks for the final network.

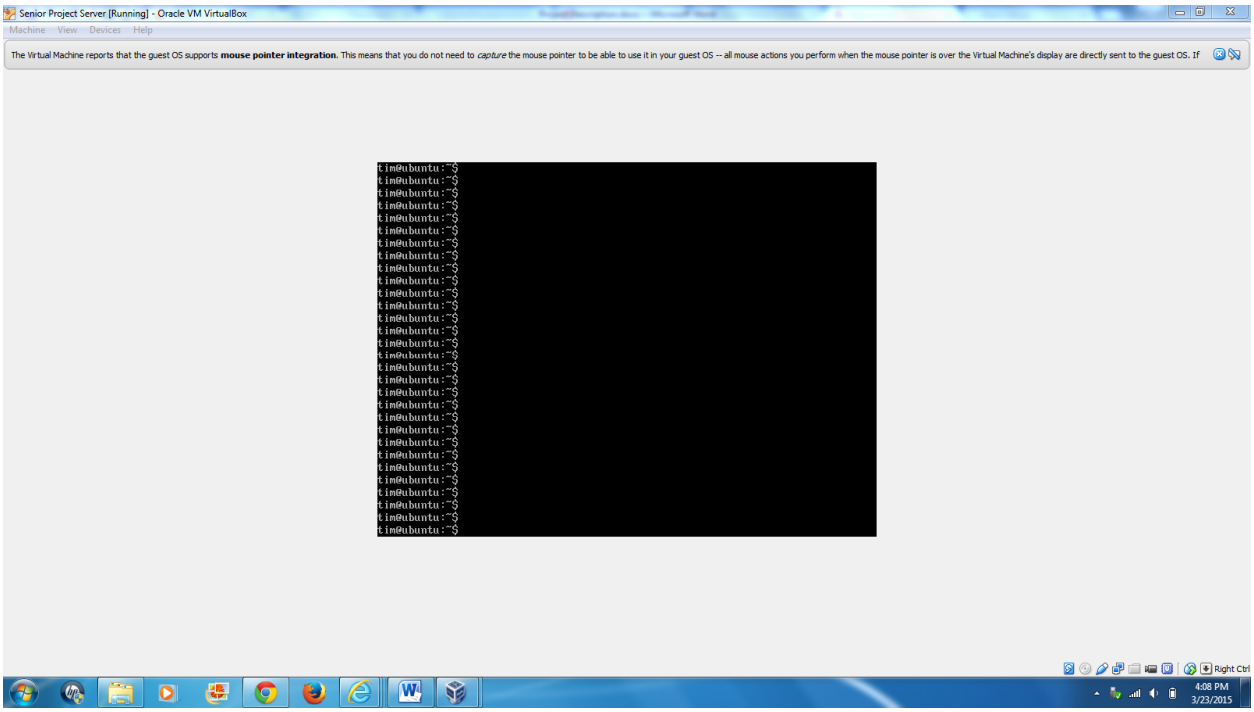


**Figure 7. Ubuntu Server installation**

The superuser was set up as tim. Another user was added using the command useradd standard. This allowed some people to access the server without administrative rights. Ubuntu allowed the installation of a DHCP server. DHCP was installed using the command sudo apt-get install isc-dhcp-server. After installation, DHCP could be configured in the file /etc/dhcp/dhcpd.conf. The following commands were added to this file to set up a DHCP server.

```
default-lease-time 600;
max-lease-time 7200;

subnet 192.168.1.0 netmask 255.255.255.0 {
 range 192.168.1.100 192.168.1.149;
 option routers 192.168.1.1;
 option domain-name-servers 192.168.1.1, 192.168.1.2;
 option domain-name "mydomain.example";
}
```

DHCP was then restarted using the command sudo service isc-dhcp-server restart. This assigned hosts on the network 192.168.1.0/24 addresses from the range 192.168.1.150 to 192.168.1.200. The router address was set to 192.168.1.254 with DNS servers at 192.168.1.1 and 192.168.1.2 and a DNS address of mydomain.example. Linux already had security applications installed. The operating system also had different monitoring tools that could be used for security. The configuration on Ubuntu involved specific server functions necessary for the final network. Samba was installed using sudo apt-get install samba. Samba was a server feature that could be used on Ubuntu to communicate with Windows clients. Since the computers used on the final network will run Windows, Samba was a useful tool for the prototype. To make the server function as a file server, the following commands were added to the file etc/samba/smb.conf.

```
workgroup = WORKGROUP
```

security = user
[share]
    comment = Ubuntu File Server Share
    path = /srv/samba/share
    browsable = yes
    guest ok = yes
    read only = no
    create mask = 0755

The workgroup command added the server to a workgroup which the Windows machine could access. The security setting allowed the Windows client access. The path command led to the file which was shared with clients. Other commands were necessary to allow the client access to this file. The directory shared with the client was added on the server using the commands sudo mkdir -p /srv/samba/share and sudo chown nobody:nogroup /srv/samba/share/. Finally, the service was started using the commands sudo restart smbd and sudo restart nmbd. These commands restarted the Samba services, allowing the new settings to take effect and enable the file server. Next, the print server could be configured using the following commands in the same file.

workgroup = EXAMPLE
security = user
browsable = yes
guest ok = yes

These commands configured Ubuntu to act as a print server. By configuring this service, the server could share a printer with client computers. The same restart commands needed to be used after this configuration to make the print server work.

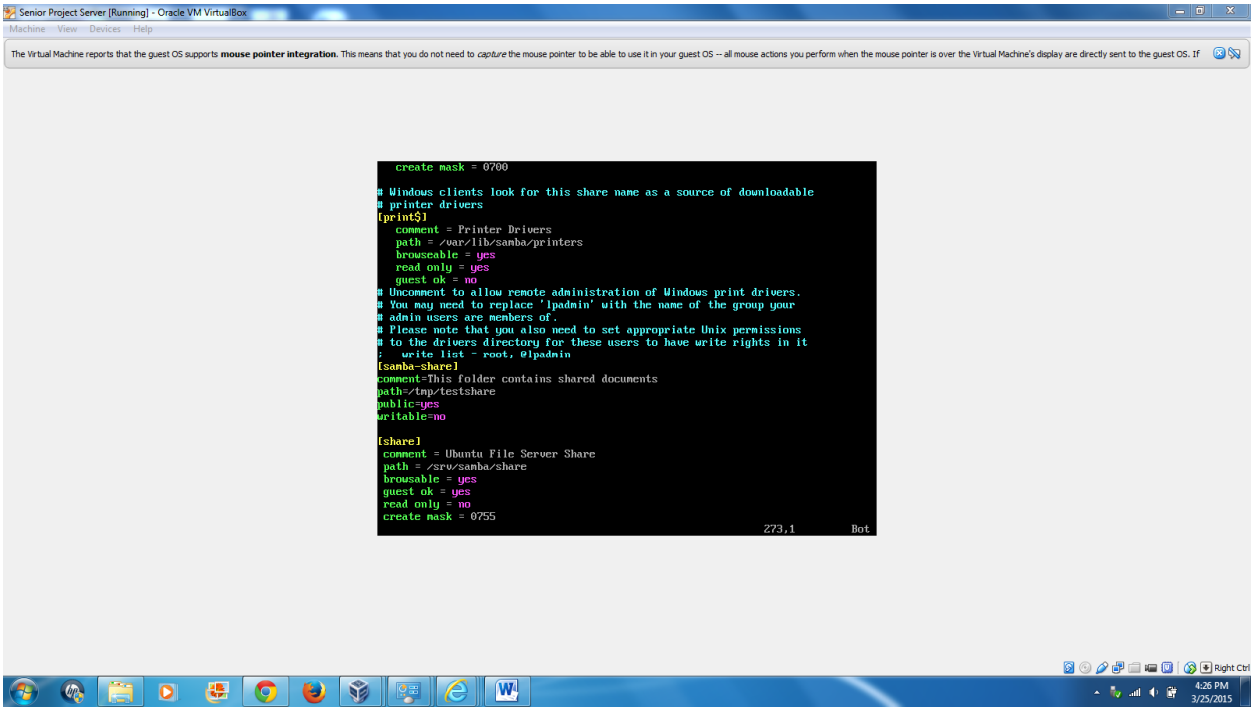



Figure 8. Samba file server configuration

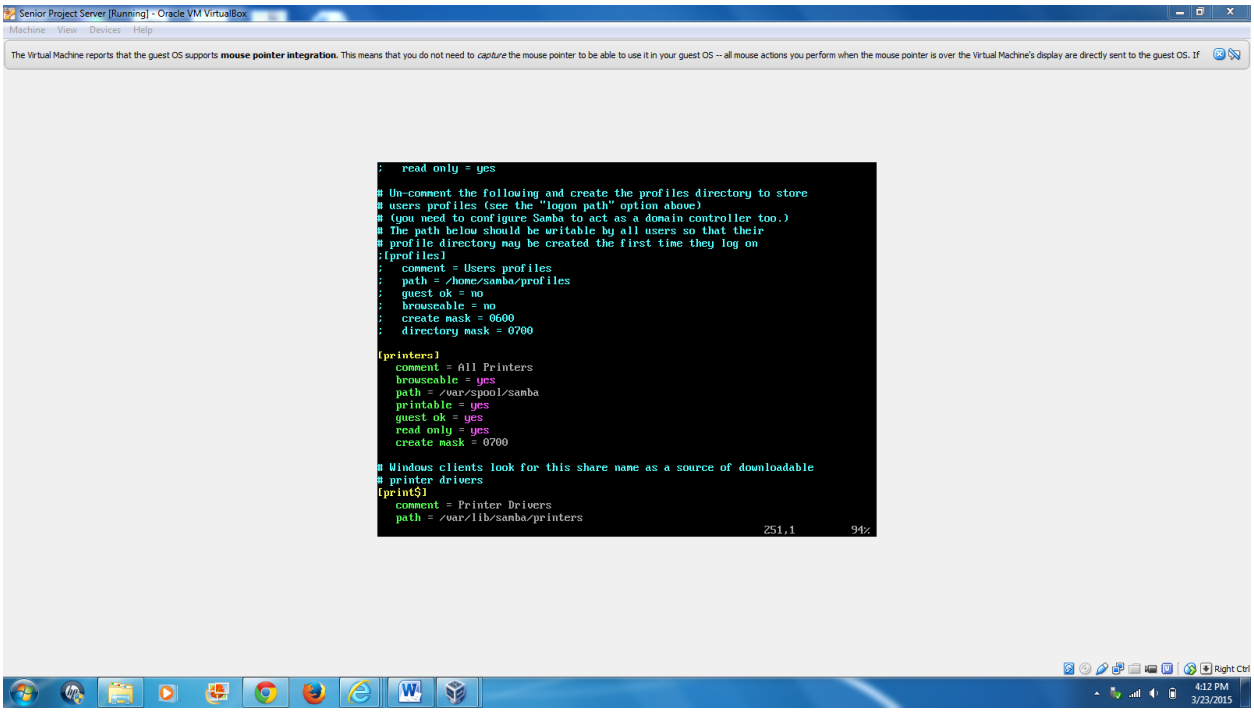



**Figure 9. Samba print server configuration**

## Wireless Router Configuration

The router could be configured by entering the authentication information from a web browser. The router that was used contained sufficient security options and the ability to handle the number of devices used on the network. This wireless router was configured with the IP address 192.168.1.1 with a /24 subnet mask. This router could also be configured to administer DHCP. When using this option, an IP address range from 192.168.1.100 to 192.168.1.149 was configured by starting from 192.168.1.100 with 50 addresses. This meant that if devices were left with DHCP configuration, they would receive an address from this range.

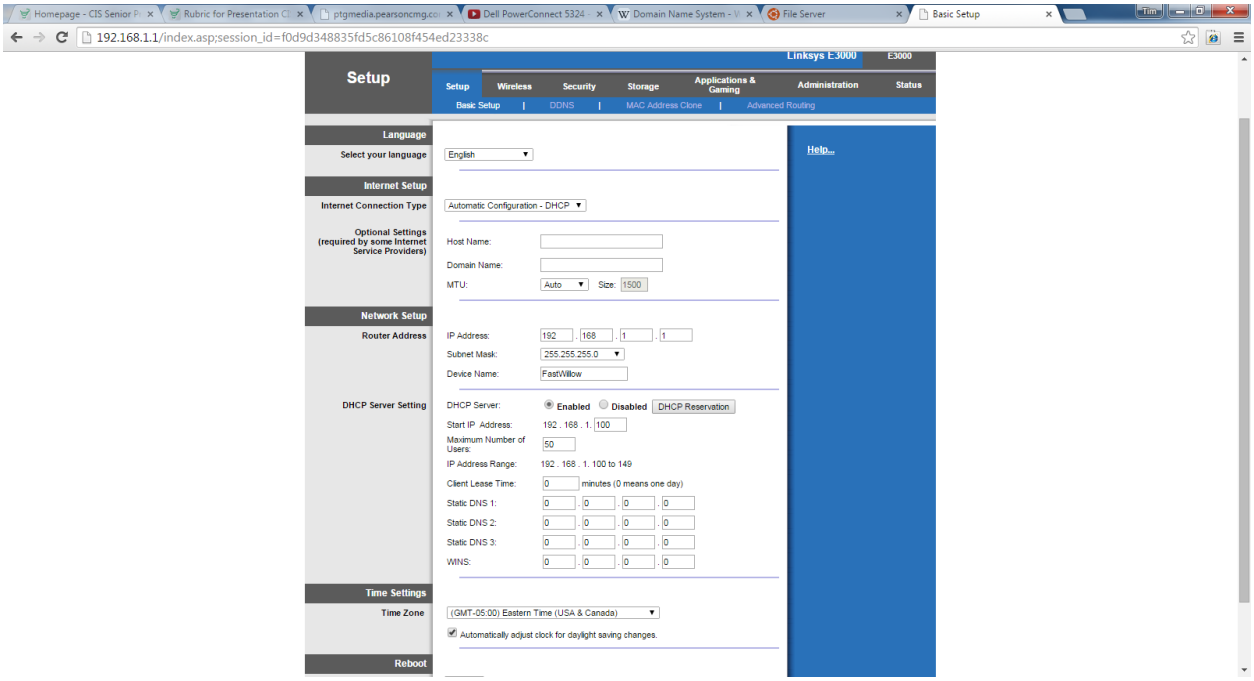



Figure 10. Router configuration

The wireless network mode was configured as Mixed with a channel width of 20 MHz. Firewall protections with some filtering was enabled. This wireless configuration would be good for the final network. The security on this router would be important to protect the final network from Internet threats. More wireless access points will probably be acquired for that network. In the final network, some wireless access points will be attached to the switch, and more computers could connect to the network through these wireless access points.

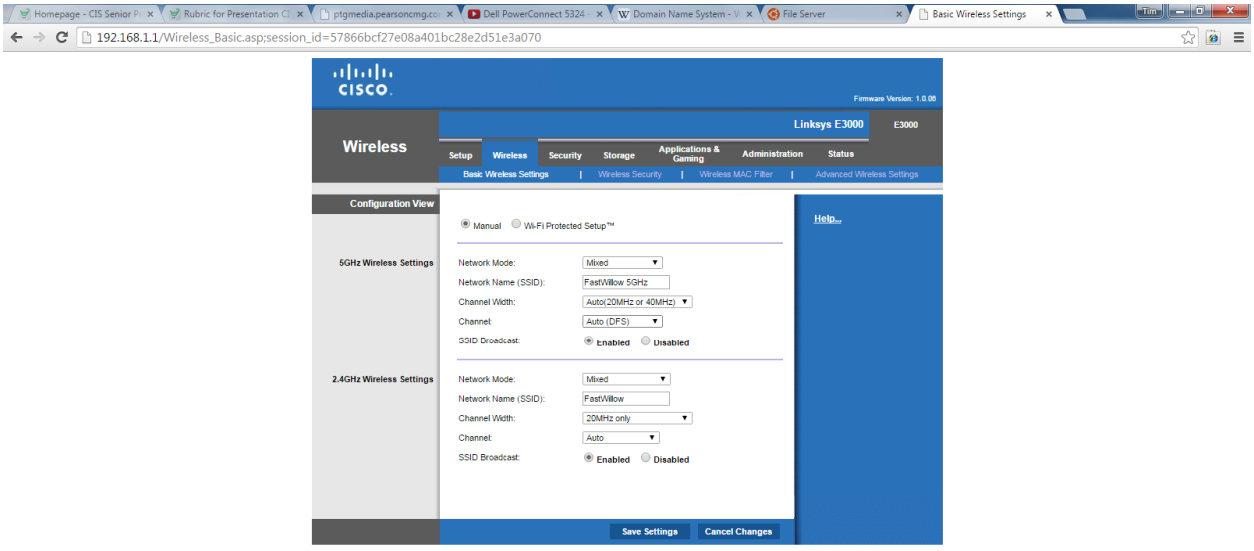



Figure 11. Wireless configuration

**Testing Documentation**

Hardware Setup

Most hardware used for the project worked, but a few problems were experienced. For one, the first USB-to-serial adapter cable did not work. This was because no drivers were available. Two cables were tried, but Windows 7 did not have any drivers available for either cable. By using the second cable on a computer with Windows XP, drivers were made available for this cable. This computer was then used to connect to the switch and configure it. In addition to this problem, the network cable between the router and the switch did not work and had to be replaced. Besides the USB-to-serial adapter cable, no major issues were experienced in the hardware setup. The main hardware components of the network functioned properly throughout the duration of the project.

Switch Configuration

The switch configuration needed to be completed from Windows XP after a new cable was acquired. The proper drivers could not be loaded on other available operating systems. HyperTerminal was used to configure the switch. All necessary configurations were completed and saved on the switch. The switch was able to connect all devices on the network.

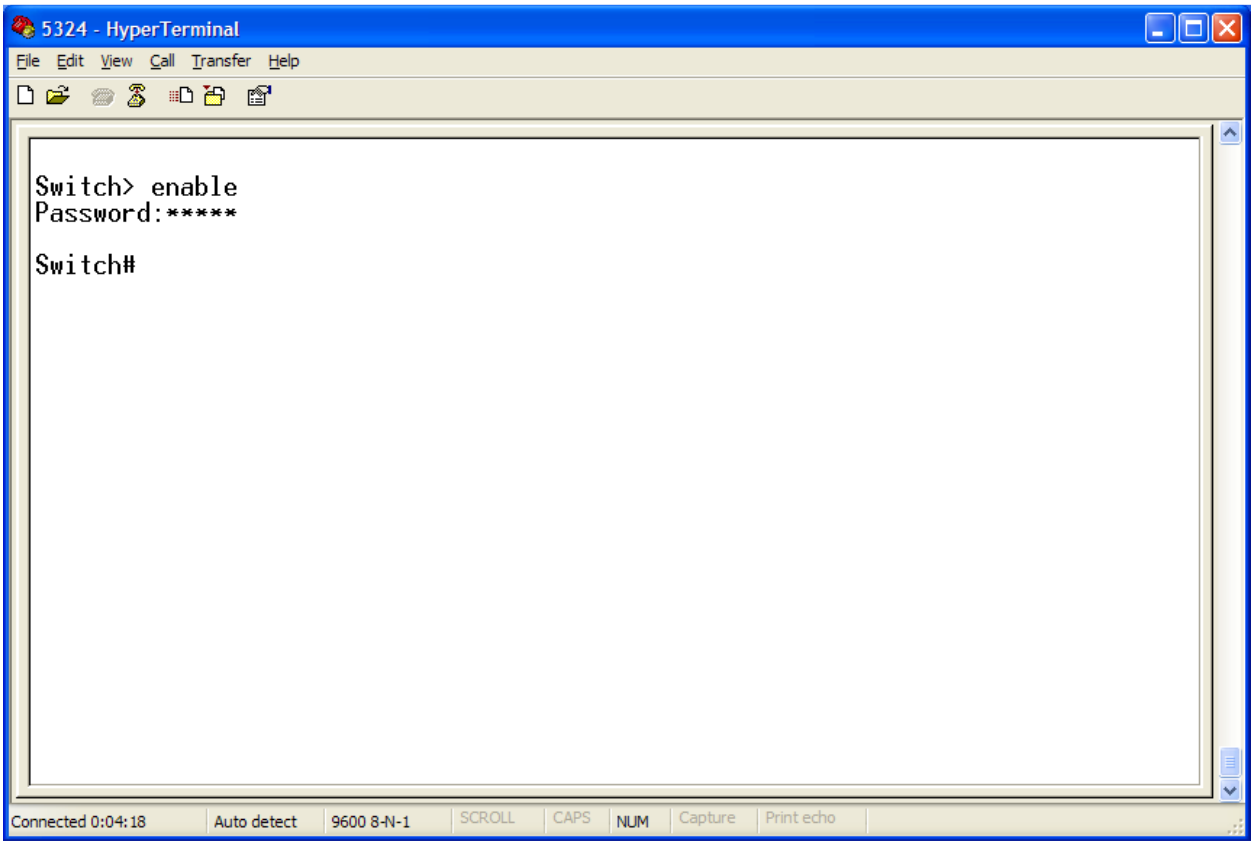



**Figure 12. Logging in to the switch after the configuration was saved**

Server and Client Functions

One of the important functions of the server was acting as a Samba server. By sharing files over the network, network users could all modify files on the server from their individual computers. Samba file and printer server configurations were completed on the server.

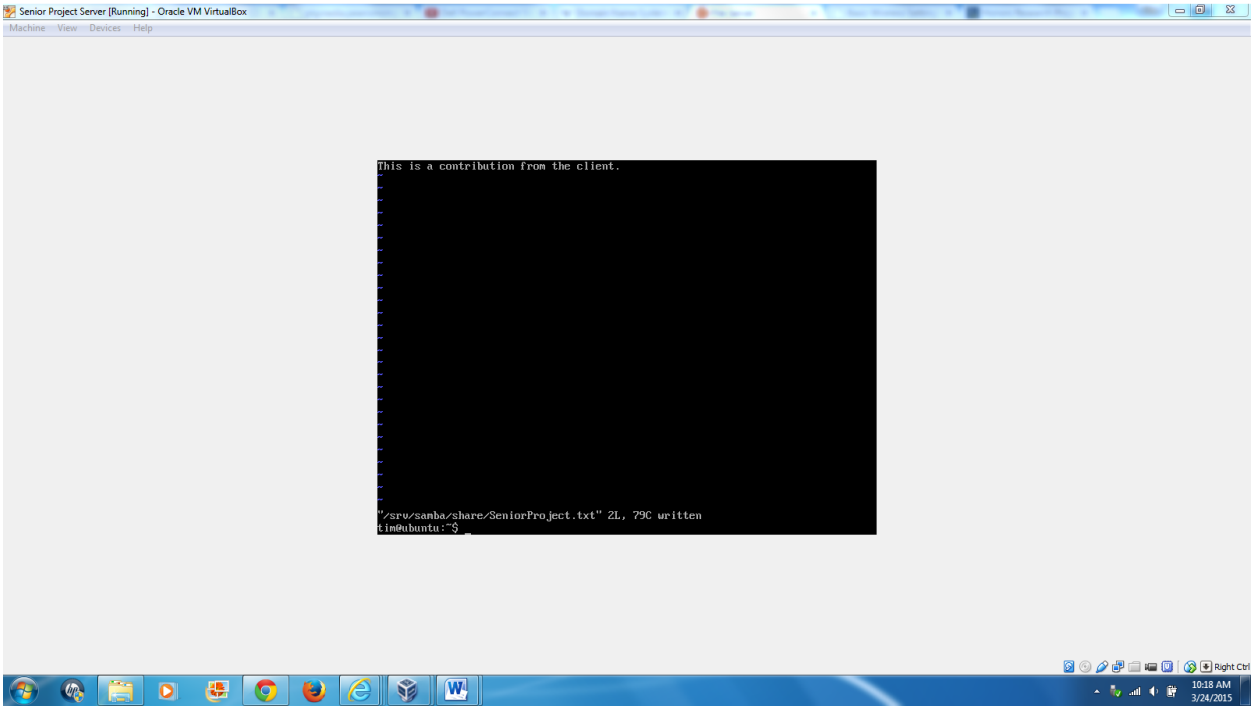



**Figure 13. Modifications from the client shown on the server**

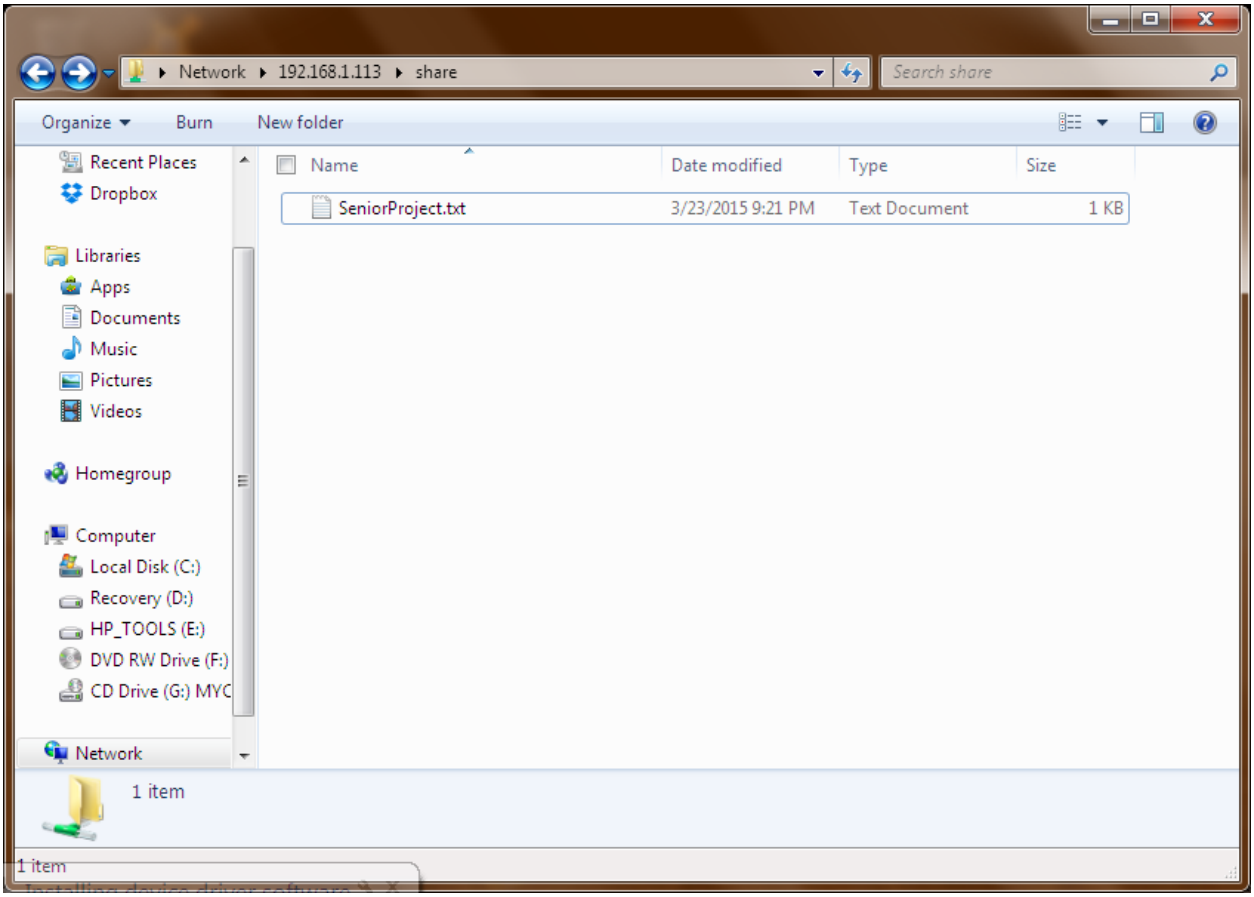



**Figure 14. Samba share from the server shown on the client**

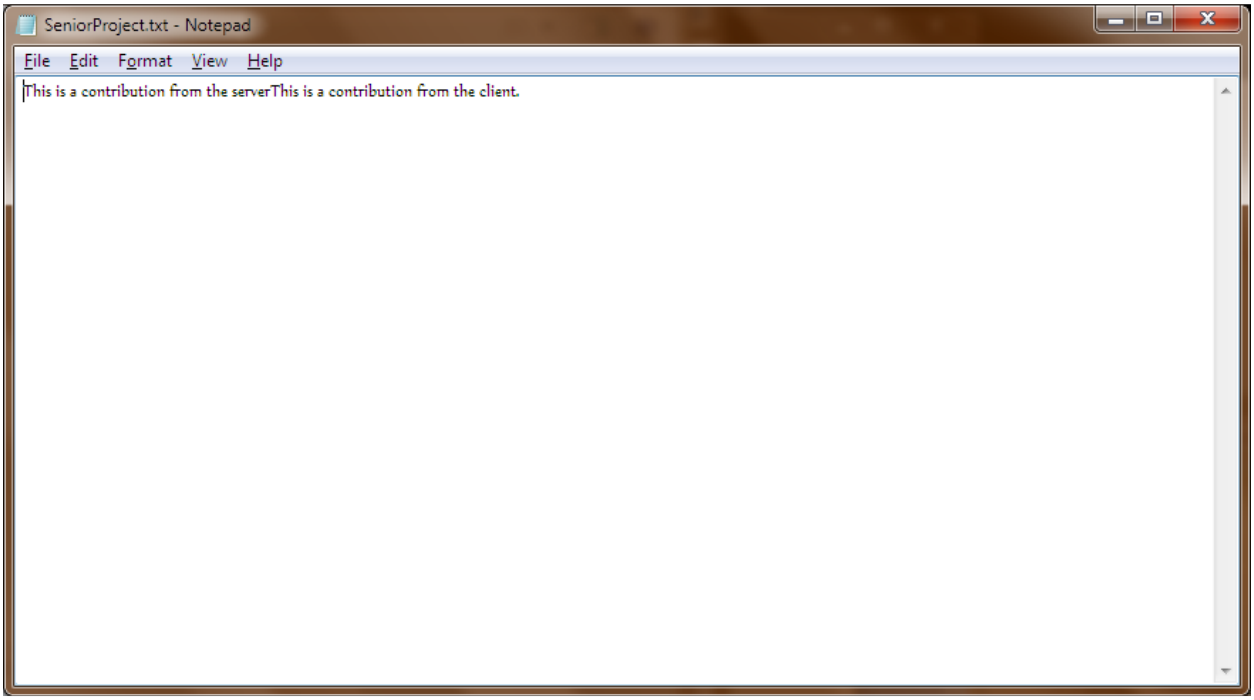



**Figure 15. File modifications from the server shown on the client**

As can be seen, the Windows client was able to connect to the Samba server over the network. The wireless router worked properly. Wireless capability functioned on all computers, and the router provided DHCP functionality to devices on the network with the address range 192.168.1.100 to 192.168.1.149.

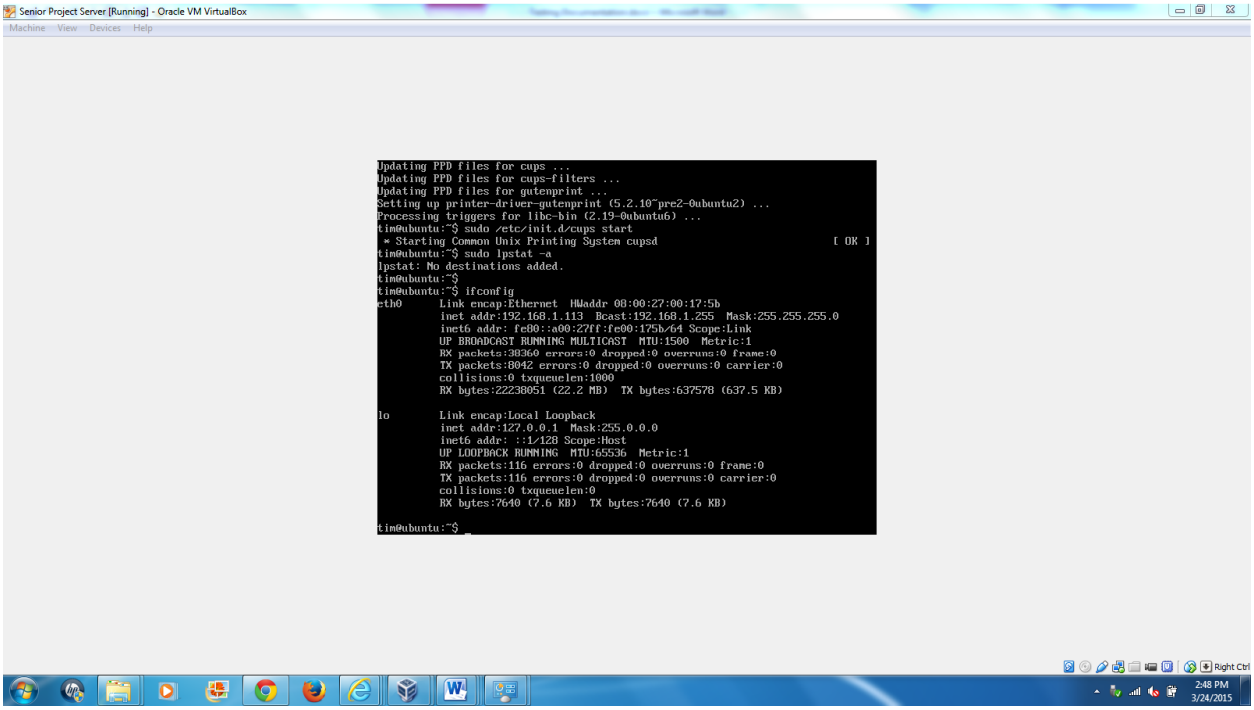



**Figure 16. Interface configuration on server**

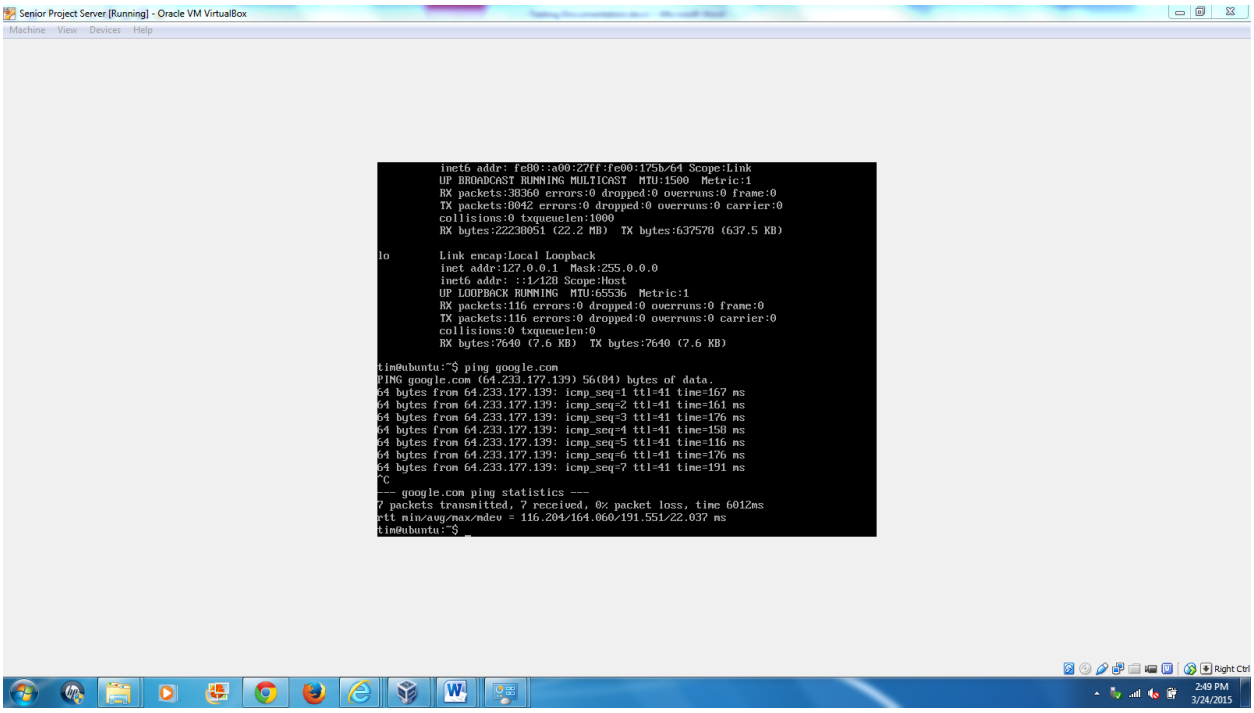



Figure 17. Server communicating to Internet

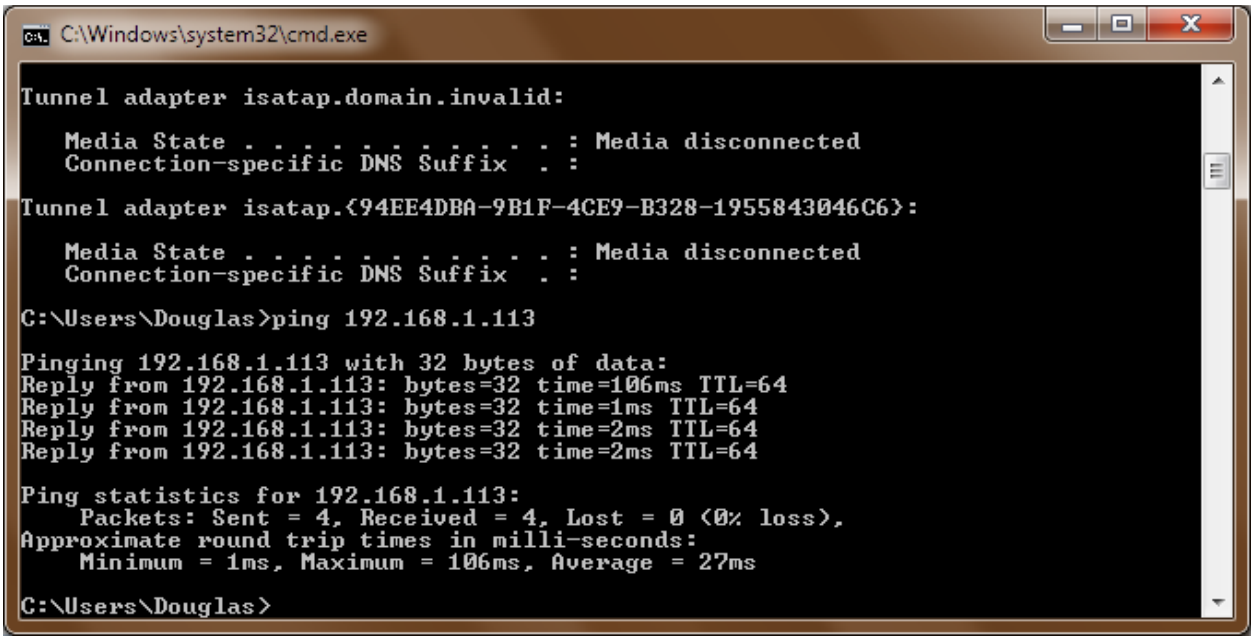



Figure 18. Client connecting to server across network

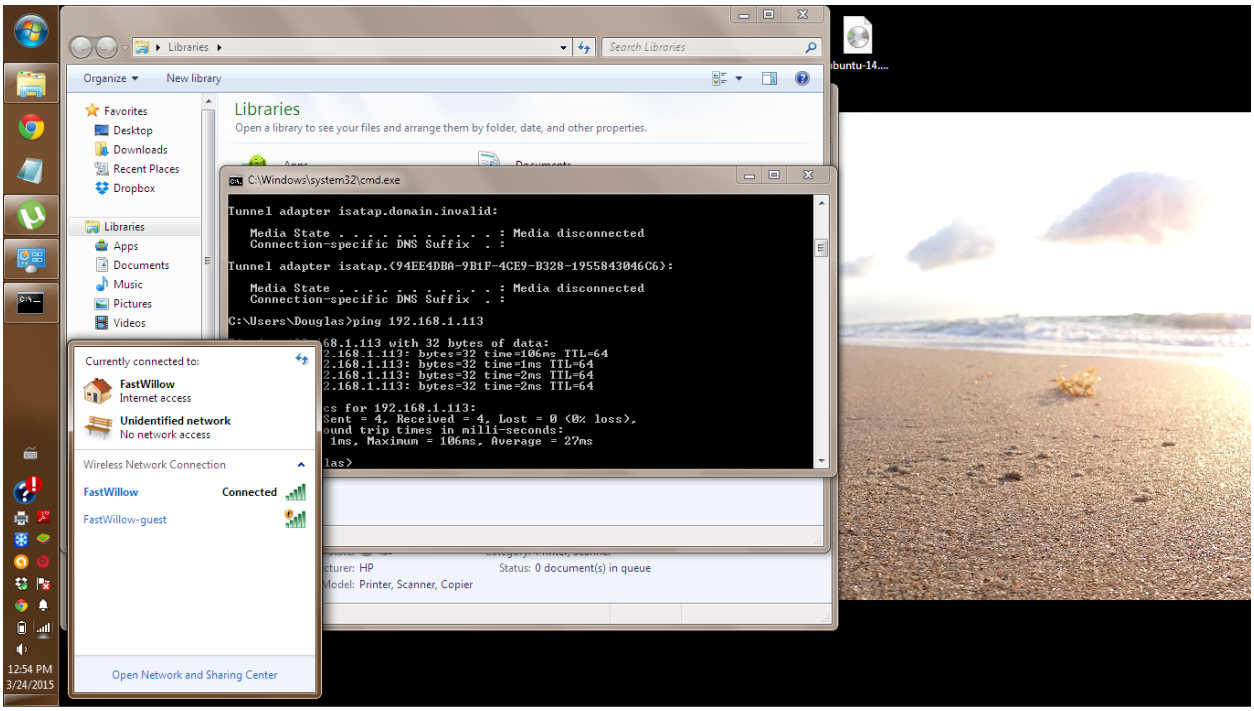



**Figure 19. Client connected to wireless network**

An HP OfficeJet 6310 printer was used on the network. It was assigned an IP address of 192.168.1.133. The printer was installed and could be connected to over the network.

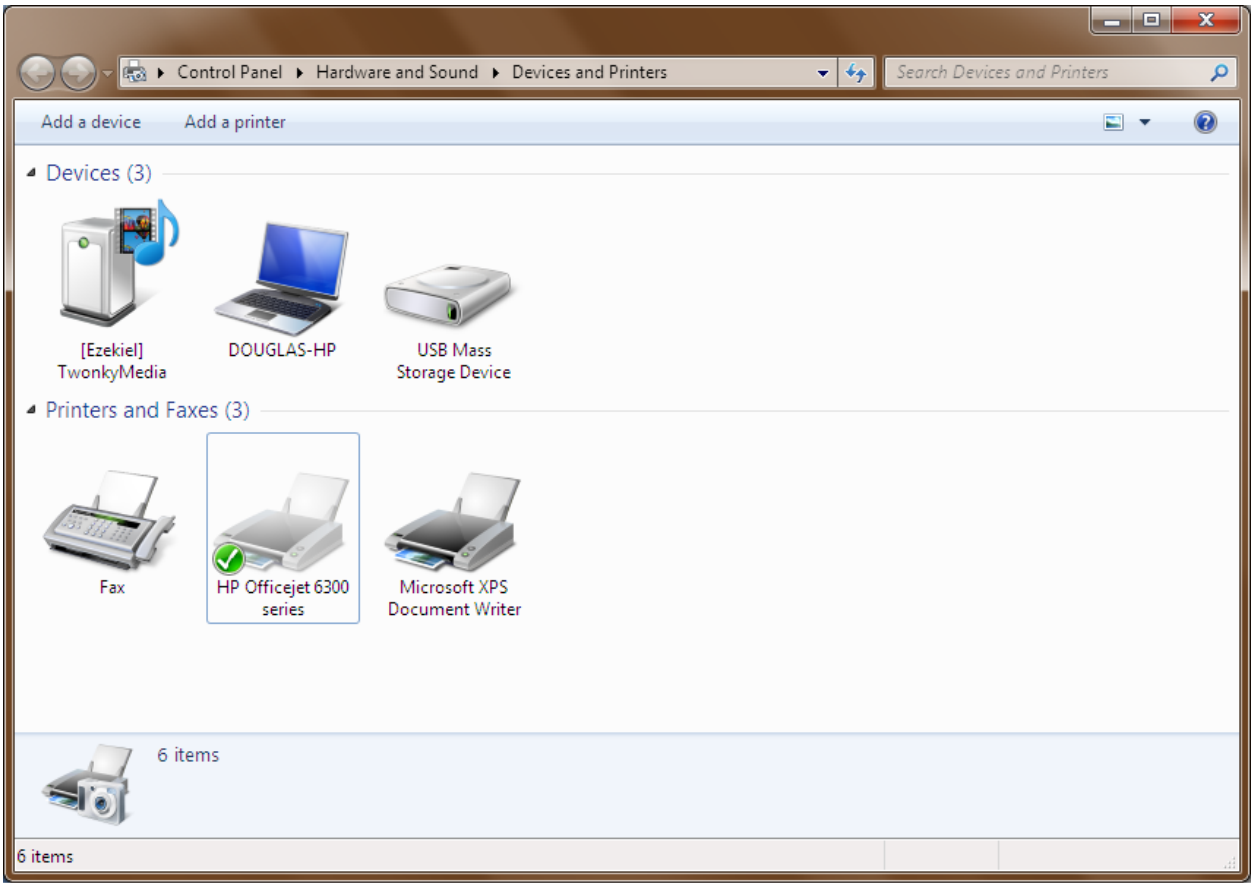



**Figure 20. Network printer displayed on the client**

A backup storage device connected to the switch on the network could also be accessed.

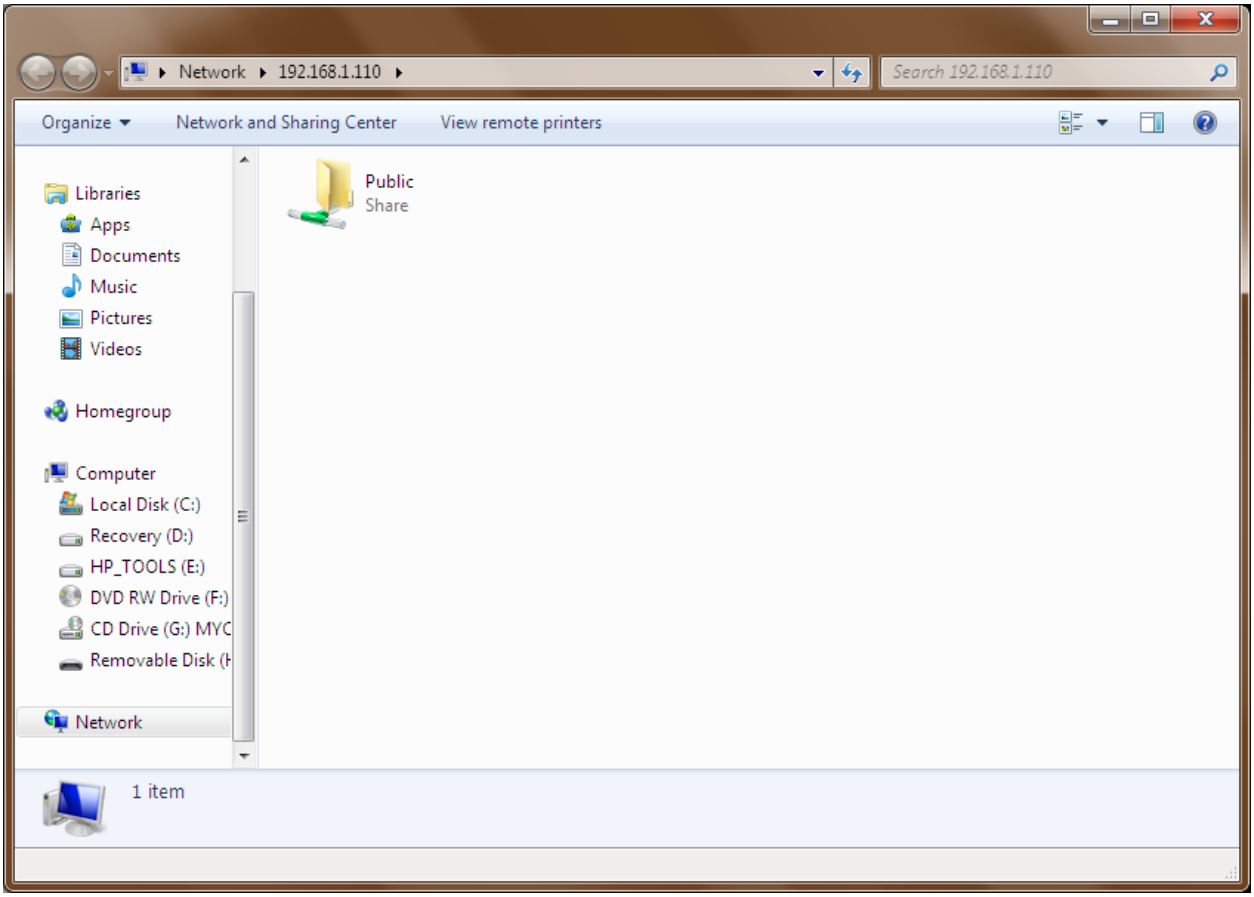



**Figure 21. Client accessing storage device over wireless network**

## Summary

The operation of devices on the network went well. One issue that occurred on the network was device performance. Although the devices could communicate, communication across the switch did not occur as quickly as it seemed that it should. For the final network, more research should be done to determine which switch and network components will provide optimal performance to the network. With all these devices functional on the network, most functions of the final church network were demonstrated. The devices that worked properly on the network that will be used on the final network included networking devices, PCs, a printer, and external storage. Other devices necessary for the final network that could not be demonstrated were wireless access points and a projector. When the time to implement the final network comes closer, more research will be done on suitable components for the final network. For this prototype network, the funds to acquire equipment were limited. In order to have better performance and more functions available on the final network, newer equipment should be acquired at a higher cost.

**Project Weekly Journals**

## Name: Tim Fuhry
## Summary – Week ending: 2/1/15

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| 1/28/15 | 3:00 | 4:00 | Borrowed switch and wireless router for use in prototype | 1 |
| 1/31/15 | 4:00 | 10:00 | Researched server requirements and began building computer for use as server | 6 |
| | | | **Total Hours This Week** | **7** |
| | | | **Total Hours to Date** | **7** |

## Journal Details

1/28/15

- Dell PowerConnect 5324 switch was acquired
- Linksys E3000 wireless router was required

1/31/15

- Ubuntu Server 14.04 on virtual machine was researched
- Computer that had been taken apart and not operational was put back together for use as server. However, this computer was eventually used as the client on the network.

**Name: Tim Fuhry**

**Summary – Week ending: 2/8/15**

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| **2/2/15** | 5:00 | 6:00 | Finished building computer for use as server | 1 |
| **2/7/15** | 1:00 | 4:00 | Researched network design, installed updates and deleted malware from server, Downloaded Ubuntu server | 3 |
| | | | **Total Hours This Week** | **4** |
| | | | **Total Hours to Date** | **11** |

## Journal Details

2/2/15

- Client computer was put together for use on network

2/7/15

- Network design with switch, router, and PCs was diagrammed
- Client computer that had been used previously was cleaned
- Client computer was updated
- VirtualBox was downloaded on server
- Virtual machine was created on server
- Ubuntu Server was downloaded onto server

**Name: Tim Fuhry**

**Summary – Week ending: 2/15/15**

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| **2/9/15** | 4:00 | 5:00 | Installed Ubuntu server, Modified network design | 1 |
| **2/10/15** | 2:00 | 4:00 | Researched server information | 2 |
| **2/14/15** | 1:00 | 2:30 | Researched and practiced using Ubuntu, Configured interfaces | 1.5 |
| **2/15/15** | 2:00 | 2:30 | Acquired network cables and binder | .5 |
| | | | **Total Hours This Week** | **5** |
| | | | **Total Hours to Date** | **16** |

## Journal Details

2/9/15

- Ubuntu Server was installed on virtual machine
- Network design was modified to use new wireless router, printer, and storage device

2/10/15

- Server functions were researched
    1. File Server
    2. Printing
    3. DHCP
    4. Network Functions
    5. Security

2/14/15

- Basic functions of Ubuntu were reviewed
- Researched and configured Ubuntu network functions and interface

2/15/15

- Network cables were acquired
- Binder was acquired
- Work on binder was planned and begun

**Name: Tim Fuhry**

**Summary – Week ending: 2/22/15**

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| **2/17/15** | 1:45 | 5:30 | Connected network equipment and server. It was determined that a new cable was needed for the switch. Worked on binder and researched information for binder. | 3.75 |
| **2/19/15** | 4:45 | 5:30 | Researched and worked on Ubuntu, Troubleshooted Ubuntu network problems | 0.75 |
| **2/20/15** | 1:45 | 3:30 | Researched and troubleshooted network problems | 1.75 |
| **2/21/15** | 9:30 | 10:15 | Ordered new cable, Worked on Ubuntu, Changed network design | 0.75 |
| | | | **Total Hours This Week** | **7** |
| | | | **Total Hours to Date** | **23** |

## Journal Details

2/17/15

- Connected network equipment to begin testing network
- Researched configuration requirements for switch
- Planned information for binder
- Researched server configuration information

2/19/15

- Researched interface configuration on Ubuntu
- Configured networking on Ubuntu

2/20/15

- Researched Ubuntu and switch requirements for networking

2/21/15

- Ordered new cable for switch configuration
- Configured Ubuntu server functions
- Worked on suitable final network design

**Name: Tim Fuhry**

**Summary – Week ending: 3/1/15**

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| **2/28/15** | 10:30, 1:00 | 11:30, 7:00 | Connected and tested switch. Troubleshooted connection and acquired new cable. Tested network connections between client and server PCs. | 7 |
| **3/1/15** | 2:00 | 4:00 | Researched and troubleshooted switch connections. | 2 |
| | | | **Total Hours This Week** | **9** |
| | | | **Total Hours to Date** | **32** |

## Journal Details

2/28/15

- Connected switch and PCs
- Tested connections to ensure computers could connect through switch
- Modified firewall settings to enable connections
- Tested new cable for switch configuration unsuccessfully

3/1/15

- Determined that new cable and computer would be required to configure switch
- Borrowed Windows XP computer for switch configuration

**Name: Tim Fuhry**

**Summary – Week ending: 3/8/15**

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| **3/7/15** | 1:00 | 4:00 | Configured switch. Worked on server. Tested network. | 3 |
| **3/8/15** | 4:30 | 5:30 | Gathered information about previous experiences with network. | 1 |
| | | | **Total Hours This Week** | **4** |
| | | | **Total Hours to Date** | **36** |

## Journal Details

3/7/15

- Finally acquired correct cable to configure switch successfully
- Configured Ubuntu server to access same network as client
- Tested current network configuration

3/8/15

- Collected network design information to be used for project
- Specified important features in final network design
- Collected troubleshooting information for project

**Name: Tim Fuhry**

**Summary – Week ending: 3/15/15**

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| **3/9/15** | 4:30 | 6:30 | Configured Ubuntu and network configuration. | 2 |
| **3/10/15** | 3:30 | 6:30 | Researched network and troubleshooted. | 3 |
| **3/14/15** | 9:00 | 5:00 | Completed network physical setup and configuration. Completed Internet configuration. Configured users on Ubuntu. Configured file server abilities. Configured printing and print server. Completed security and networking configurations on switch. | 8 |
| | | | **Total Hours This Week** | **13** |
| | | | **Total Hours to Date** | **49** |

## Journal Details

3/9/15

- Determined important features for final network configuration
- Configured network features in Ubuntu

3/10/15

- Troubleshooted network connection problems

3/14/15

- Completed configuration of file and print server on Linux
- Configured DHCP and wireless connectivity
- Configured additional users on server
- Attached printer to network
- Completed testing configurations on switch

**Name: Tim Fuhry**

**Summary – Week ending: 3/22/15**

| Date | Start Time | End Time | Description | Total Hours |
|---|---|---|---|---|
| **3/17/15** | 1:00 | 2:00 | Did work on planning for binder. | 1 |
| **3/21/15** | 10:00 | 6:00 | Completed network configuration. Worked on project analysis and references. | 8 |
| **3/22/15** | 1:00 | 7:00 | Worked on storage and did some server work. Completed project analysis and presentation. | 6 |
| | | | **Total Hours This Week** | **15** |
| | | | **Total Hours to Date** | **64** |

## Journal Details

3/17/15

- Completed design planning for binder

3/21/15

- Completed configuration of server and client
- Did rough draft of project analysis
- Started organizing reference information into References list

3/22/15

- Attached and tested storage device
- Tested some server functions
- Completed project analysis
- Completed project presentation

**Research References**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